Development of Multi-Mode Bending Flex Communication System using Arduino Mega with SMS Module

A Proposed Study Submitted to the Faculty of Computer Engineering Department Bestlink College of the Philippines In Partial Fulfilment of the Requirements for the Degree of Bachelor of Science in Computer Engineering

(By Group 6)

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CHAPTER 1

INTRODUCTION

In the realm of advancing technology, ensuring accessible communication is crucial, particularly for individuals facing mobility impairments and their daily challenges. The Development of a Multi-Mode Bending Flex Communication System using Arduino Mega with SMS Module stands as a pioneering solution, utilizing sophisticated components to empower its users with efficient communication capabilities.

At its core, this innovative system integrates four strategically placed flex sensors into a specialized glove, enabling precise gesture articulation for specific functions. Each finger flexion represents a distinct command, such as requesting water, signaling bathroom breaks, or controlling lights. This intuitive gesture recognition system enhances user interaction, providing a streamlined means of communication.

Through meticulous component integration, the Multi-Mode Bending Flex Communication System encouraged conventional aids, offering a personalized interaction platform. Beyond immediate needs, it includes advanced features for continuous health monitoring and safety. This system were made with the care towards inclusivity and empowerment, enabling individuals with mobility impairments to navigate daily life with convenience, confidence, and enhanced communication capabilities.

BACKGROUND OF THE STUDY

Bitling Prakash, (2023) proposed a study the necessity to address the daily challenges encountered by the elderly and individuals with mobility impairments. It recognizes the limitations faced in tasks such as eating, bathroom breaks, light control, and physical assistance. The research initiates from the acknowledgment of the crucial role that technological advancements play in creating a more inclusive and supportive environment for individuals with mobility limitations.

An evident gap exists in the domain of assistive technologies tailored to the needs of the elderly and those with mobility impairments. While numerous solutions are available, there is a scarceness of comprehensive systems that seamlessly integrate communication, control, and assistance functionalities. Existing technologies often lack intuitive and user-friendly interfaces for individuals facing mobility challenges, highlighting the necessity for a more refined and adaptable solution.

The envisioned system has significant potential to benefit society by addressing the specific challenges encountered by the elderly and individuals with mobility impairments. By offering a comprehensive solution that integrates communication, control, and assistance functionalities, the research focuses on empowering individuals to navigate daily tasks with greater ease and confidence. The societal impact of such an innovation extends beyond individual users to include caregivers, healthcare providers, and community support networks, fostering a more inclusive and supportive environment for all individuals regardless of mobility status. Ultimately, the research seeks to contribute to the advancement of assistive technologies and promote greater independence and well-being for individuals with mobility limitations.

Theoretical Framework

According to **Yakubu, et al ., (2021)** The rise of the Internet of Things (IoT) has led to an increased adoption of digital healthcare systems, facilitating remote monitoring of patients' health conditions. This paper introduces an intelligent and automated IoT-based system for monitoring vital signs, focusing at enhancing patient care. A theoretical framework was developed to guide the creation of a prototype, which includes components such as the patient, IoT sensors, input and storage unit, and data processing, analysis, and transmission mechanisms. The prototype is designed to detect real-time body temperature, heart rate, and respiration rate, transmitting this data to a cloud repository for storage and analysis. Caregivers are alerted via SMS, email, and voice calls in cases requiring immediate attention, with voice calls added to ensure alerts are promptly received, considering the potential delay in checking SMS and email. To safeguard patient privacy, caregiver access is restricted to biometric verification, either through fingerprint or facial recognition. Experimental findings validate the accuracy of the prototype's data collection and confirm the enhanced privacy protection compared to existing benchmark systems.the prototype's data collection and confirm the enhanced privacy protection compared to existing benchmark systems.

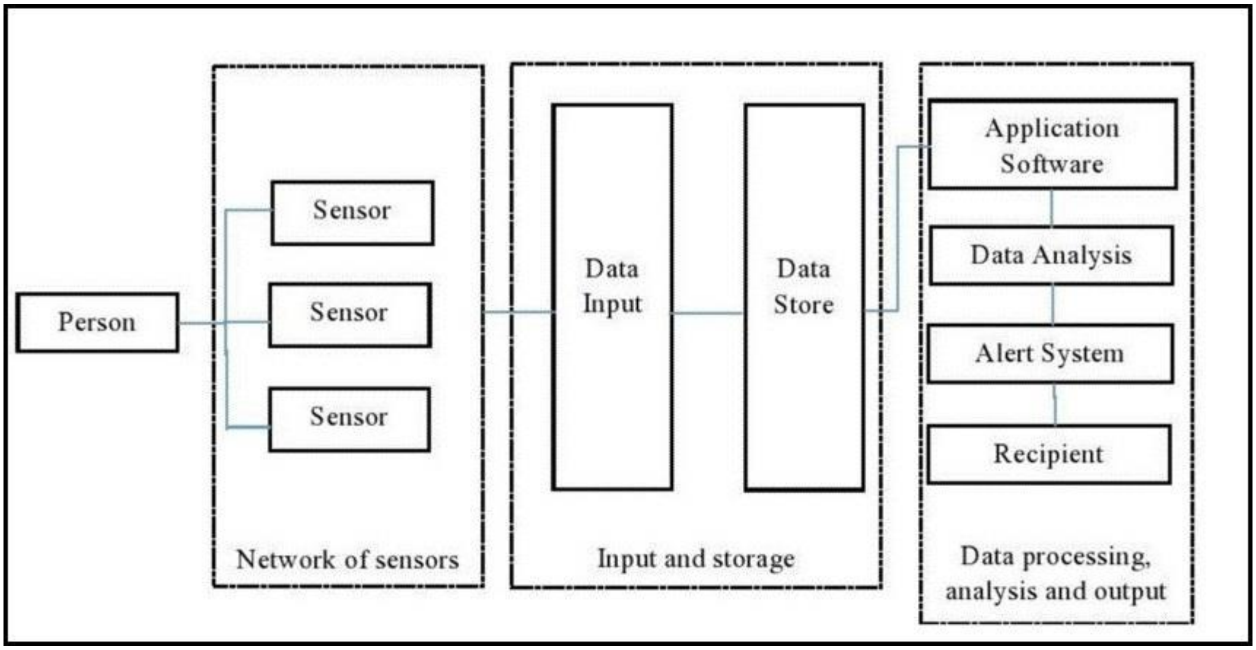

Figure 1.0 Vitals Monitoring System based on IoT (Internet of Things)'

Conceptual Framework

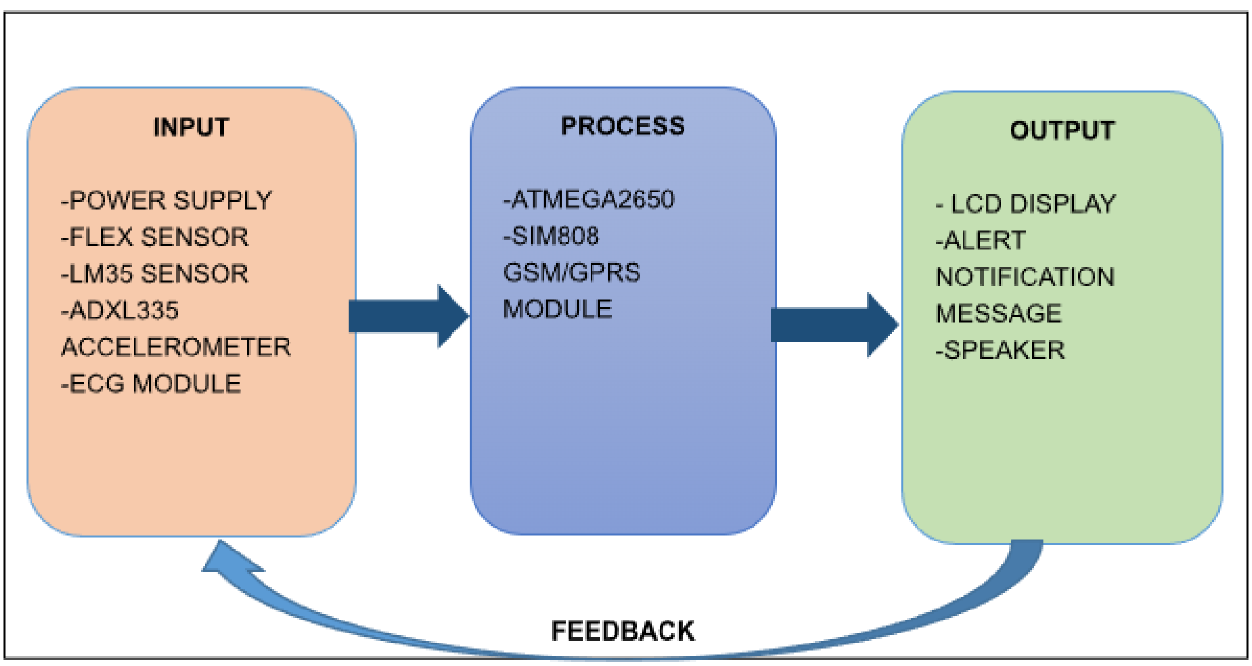

Figure 1.1 Paradigm of the Study

The system integrates various sensors such as Flex, ADXL335, and ECG modules, powered by a reliable source. Processing is managed by the ATMEGA2650 microcontroller and SIM808 GSM GPRS module.

Outputs include real-time display on an LCD, alerts, notification messages, and audible feedback through a speaker, ensuring efficient data flow for monitoring and response.

Review of Related Study and Literature

This chapter includes ideas, a finished thesis, generalizations or conclusions, methodologies, and others.

Foreign Study

In the words of **Yakubu, et al ., (2021),** in the contemporary digital landscape, the Internet of Things (IoT) stands as a pivotal and often debated concept. Its essence lies in enabling the connection of various devices and physical objects to the internet, ushering in an era where everyday items become interconnected nodes in a vast network. This paradigm shift towards connectivity and automation has been made possible by the virtualization of numerous systems, allowing tasks to be performed remotely without the need for direct physical interaction. The integration of high-speed internet and intelligent technologies has further facilitated this transition, offering a seamless management of tasks across distances.The advent of IoT brings with it a plethora of benefits, from enhanced efficiency to improved convenience. However, it also presents a unique set of challenges that must be addressed for its widespread adoption and successful implementation. In response to these challenges, there is a growing need for innovative solutions that can effectively manage and supervise IoT deployments, particularly in domains like smart home automation.This paper proposes a hybrid supervisory system that combines local and remote functionalities to create an efficient and cost-effective solution for IoT-managed smart homes. Central to this proposal is the development of an algorithmic framework that enables remote monitoring of household conditions and the automated control of appliances via the internet. The system architecture utilizes an ATmega 2560 microcontroller unit as a Wi-Fi-based gateway, facilitating seamless communication between sensors and the centralized control hub. By leveraging this proposed system, homeowners can enjoy the benefits of IoT-enabled automation while mitigating the complexities associated with its deployment. Real-time data collection and analysis empower users with actionable insights, enhancing both the efficiency and intelligence of their living spaces. In essence, this hybrid supervisory system represents a significant step towards the realization of a truly interconnected and intelligent future.

In their dedicated study published in **2023, Bitling Prakash** presented a revolutionary prototype that takes a positive insight at transforming communication for elderly and immobile individuals. Through the innovative utilization of an Arduino Mega-based project, Prakash introduced a sophisticated system comprising an ECG module for continuous heart rate monitoring, an accelerometer meticulously engineered for precise fall detection, an LCD module providing intuitive visual feedback, and a high-fidelity speaker for crystal-clear audible notifications. This comprehensive solution effectively addresses the critical need for enhanced communication between caregivers and their charges, facilitating seamless real-time monitoring and immediate assistance for individuals facing mobility limitations. By seamlessly integrating cutting-edge technologies into a single, user-friendly platform, Prakash's prototype not only elevates the quality of life for those with mobility challenges but also offers invaluable peace of mind to caregivers and concerned family members. Furthermore, the prototype incorporates advanced features such as remote monitoring capabilities, allowing caregivers to access vital health data and receive alerts remotely, ensuring round-the-clock support and intervention when necessary. The intuitive interface and user-friendly design make it accessible to individuals with varying levels of technological proficiency, empowering them to take control of their health and well-being.Moreover, Prakash's prototype has the potential to revolutionize the field of elderly care by providing a cost-effective and scalable solution to the growing challenge of caring for aging populations. Its innovative approach not only improves the efficiency of caregiving but also fosters greater independence and autonomy for elderly individuals, enabling them to age in place with dignity and grace.

In a study published in **2021, Kumar et al.** made significant strides in advancing assistive technologies through their innovative IoT-based system. Their research plans to bridge the communication gap between immobile patients and caregivers, utilizing cutting-edge LabVIEW Software and GSM technology. By ingeniously enabling hand movements to trigger SMS messages directly to caregivers, Kumar et al.'s system offers a lifeline to individuals with limited mobility, ensuring prompt assistance and support. Their work, presented at the esteemed 2021 3rd International Conference on Advances in

Computing, Communication Control, and Networking, represents a pivotal breakthrough in the realm of remote communication solutions. Its versatility and affordability render it accessible to individuals with diverse needs, including those with mobility impairments, visual impairments, and even COVID-19 patients. By revolutionizing communication and support for individuals facing mobility challenges, this innovative approach holds immense promise in significantly enhancing their quality of life and providing timely assistance in critical situations. With the evolution of high-precision sensors and the proliferation of Internet of Things (IoT) enabled medical devices, healthcare has undergone a notable shift from the conventional center-based model to a more decentralized approach. These compact IoT healthcare devices have significantly diminished the overall cost of healthcare services, thereby enhancing affordability and fostering broader adoption. This paper delves into the latest advancements in the architecture and system design of IoT-based healthcare systems. It explores various healthcare frameworks such as mHealth and 6LoWPAN-based architectures, along with systems utilizing IEEE 11073 and Constrained Application Protocol (CoAP). Additionally, it investigates multisensor-based system designs capable of monitoring parameters like blood glucose levels, body temperature, heart rate, and electrical activity (ECG). By providing a comprehensive overview of recent breakthroughs in IoT-based healthcare systems, the paper also proposes a novel healthcare system design centered around the Intel Curie platform, further pushing the boundaries of innovation in this critical domain.

Addressing the communication challenges encountered by individuals with motor coordination disabilities, **Srinivasan et al.**, proposed an ingenious solution that serves as a lifeline for those struggling with traditional communication methods such as speech or sign language. Through the utilization of technology, their system enables disabled individuals to initiate the transmission of text messages on an LCD display using any movable part of their body.What distinguishes this system is its seamless operation even in scenarios where direct assistance is unavailable. With the integration of GSM technology, users gain the ability to send SMS messages to caregivers, healthcare providers, therapists, or family members, ensuring that assistance is readily accessible. Furthermore, the system's advanced tilt detection mechanism accurately discerns the user's body movements, thereby enhancing its efficacy in facilitating communication.

By empowering individuals with motor coordination disabilities to communicate effortlessly, Srinivasan et al.'s system unlocks numerous opportunities for enhanced interaction and support. Whether connecting with healthcare professionals or reaching out to loved ones, this innovative solution bridges the communication divide, fostering greater independence and accessibility for individuals with disabilities.

Beyond its immediate practical applications, this technology also holds promise for improving the overall quality of life for individuals with motor coordination disabilities. By providing a means for self-expression and connection, it promotes social inclusion and enhances emotional well-being. Additionally, its versatility and adaptability make it suitable for use in various settings, including healthcare facilities, rehabilitation centers, and home environments. Through continued innovation and refinement, this system has the potential to revolutionize communication for individuals with motor coordination disabilities, offering them newfound independence and agency in their daily lives

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.**Joyantee et al. (2020)** embarked on a groundbreaking endeavor to develop an Arduino-based signaling system tailored exclusively for individuals facing physical challenges. Recognizing the paramount importance of safety and well-being, particularly in regions prone to accidents, their project serves as a beacon of hope during emergencies. Leveraging the formidable capabilities of Arduino Uno technology, their innovative system swiftly dispatches notifications to emergency contacts, hospitals, and ambulances, thereby expediting response times and enhancing accessibility for those with physical disabilities.One of the pivotal strengths of this project lies in its versatility and adaptability to diverse scenarios and needs. For instance, it excels at promptly alerting parents when children with special needs stray from designated areas, instilling peace of mind and ensuring timely intervention as necessary. By catering to such specific requirements, the signaling system not only delivers immediate support but also lays the foundation for future advancements in assistive technologies.In essence, **Joyantee et al.,** project signifies a monumental leap forward in the domain of assistive technologies, offering a lifeline to individuals grappling with physical challenges and their caregivers alike. Through its innovative design and multifaceted functionality, the Arduino-based signaling system holds the promise of significantly enhancing safety, fostering independence, and ushering in a more inclusive society.

Local Study

In the study of **Cruz et al., (2023)** endeavors to create a device that assists immobile individuals and the elderly in communicating their basic needs effectively and independently. The primary objective is to leverage available technology to enhance understanding and communication methodologies for users while offering an alternative, cost-effective approach to rehabilitation. Traditional care methods often incur significant expenses, prompting the exploration of solutions utilizing affordable materials without compromising essential care standards. The envisioned device takes the form of a microcontroller-based hand gesture system equipped with sensors positioned on the user's hand and fingers. These sensors serve as the principal means of communication between the user and their caregiver or support personnel. Through intuitive hand gestures, users can trigger pre-programmed messages displayed on an LCD screen, allowing them to convey their needs with ease. Moreover, the system incorporates SMS notification capabilities to alert caregivers promptly if they are not in immediate proximity to the user. This feature ensures that assistance is readily available whenever required, fostering a sense of security and peace of mind for both users and caregivers alike. Additionally, the device offers flexibility through customizable messages, accommodating the diverse needs and preferences of users in their daily lives.By providing a reliable and user-friendly communication platform, this innovative solution aims to promote independence, dignity, and improved quality of life for immobile individuals and the elderly. Through the strategic integration of technology, it seeks to empower users while offering a practical and efficient means of care and support.

Foreign Literature

Mohammad Faisal Ahmed (2022) highlighted the escalating health hazards faced by individuals, particularly due to the absence of regular health monitoring, exacerbating issues such as heart rate irregularities and oxygen level fluctuations. This predicament is especially dire for older individuals with limited mobility, who often require round-the-clock supervision, posing significant challenges in terms of time and resources. To mitigate these challenges and address the pressing need for continuous health monitoring and timely intervention, this paper proposes an innovative IoT-based solution in the form of a smart hand glove.This device is designed to enable continuous monitoring of vital health parameters such as oxygen saturation (SpO2) and heart rate levels through integrated sensors. Additionally, the glove incorporates a fall detection mechanism to swiftly identify potential accidents, providing an added layer of safety and security for users. Notably, the glove's design allows users to convey urgent needs, such as "Need Food" or "Need Assistance," through intuitive hand movements, further enhancing the device's functionality and usability.The collected health data is transmitted to designated devices via email or SMS alerts, ensuring that caregivers or healthcare providers are promptly notified in case of any abnormalities or emergencies. Moreover, the glove's IoT capabilities allow for seamless integration with existing healthcare systems, facilitating better coordination and communication between users, caregivers, and medical professionals.By providing real-time health monitoring and a means of communication for elderly and immobile individuals, this smart hand glove has the potential to significantly improve their overall well-being and quality of life. It addresses the critical need for personalized and accessible healthcare solutions, empowering users to live more independently and confidently while fostering a greater sense of security and peace of mind.

Ashwini Wadhai et al. (2022) introduced a novel approach to improving people's well-being by harnessing electronic innovation to optimize patient monitoring and reduce reliance on manual intervention. Their groundbreaking method utilizes GSM (Global System for Mobile Communications) technology as a cornerstone for facilitating real-time communication between patients and healthcare providers. Through this technology, any deviations in health parameters automatically trigger pre-configured messages to be dispatched to designated recipients, ensuring timely notification and intervention in case of emergencies or critical health events. Furthermore, the system incorporates a GPS (Global Positioning System) module, seamlessly integrated into the framework, to enable continuous monitoring of the patient's location. This feature ensures that healthcare providers can track the patient's whereabouts even in remote or inaccessible areas, thereby facilitating swift assistance and support regardless of geographical constraints. The functionality of the system extends beyond basic communication to encompass comprehensive health monitoring capabilities. Patients' vital signs, including temperature, heart rate, and voltage levels, are continuously monitored and logged by the system. This aspect of the system is particularly beneficial for patients requiring regular health checks or those with chronic health conditions who need continuous monitoring and management in a home setting.In emergency situations, such as sudden changes in health status or critical incidents, the system is equipped to send SMS alerts to predefined recipients, including healthcare professionals and family members. This prompt notification mechanism enables swift intervention and ensures that appropriate actions can be taken promptly to address the situation and provide the necessary assistance to the patient.Moreover, the system features an innovative interface that utilizes an accelerometer embedded in a glove worn by the patient. This accelerometer interprets tilt direction, allowing users to initiate communication or send messages by simply tilting their smartphone at specific angles. These motion statistics are transmitted to a central microcontroller, which processes the data, displays relevant information on an LCD screen, emits audible alerts through a buzzer, and sends SMS notifications to registered caretakers as needed.Overall, **Ashwini Wadhai et al.'s** integrated approach to patient monitoring and communication represents a significant advancement in healthcare technology. By combining advanced electronic components with robust communication protocols, their system enhances patient care, promotes proactive health management, and fosters improved outcomes across diverse healthcare scenarios.

Karamchandani et al. (2023) proposed a comprehensive model tailored for the continuous monitoring of vital health parameters and environmental conditions, aimed at enhancing the overall well-being and safety of individuals in various healthcare settings. The cornerstone of their model lies in its ability to monitor critical health metrics such as heart rate, blood oxygen levels, and environmental factors including CO_2 gas levels, room temperature, and humidity, all of which are displayed in real-time on a user-friendly LCD interface.In addition to its robust health monitoring capabilities, the model incorporates an advanced alert mechanism designed to promptly notify registered caregivers in the event of detected toxic gases or hazardous environmental conditions. This proactive alert system plays a crucial role in preventing potential accidents and ensuring the safety of individuals under care by facilitating timely intervention and mitigation measures.

Furthermore, **Karamchandani et al.'s** model addresses the unique needs of vulnerable populations such as the elderly, deaf, mute, bedridden, and individuals with mobility issues by introducing an innovative glove embedded with flex sensors. These sensors are strategically positioned to correspond to specific areas of the hand, enabling them to detect subtle movements and gestures made by the wearer. When activated, each flex sensor triggers auditory feedback, providing a seamless and efficient means of communication between patients and their caregivers.By leveraging this innovative glove technology, caregivers can effectively interpret and respond to the needs and signals expressed by immobile individuals, thereby enhancing the overall quality of care and support provided to this demographic. This tailored approach not only promotes greater independence and autonomy for individuals with mobility limitations but also fosters a more compassionate and responsive caregiving environment. In summary, **Karamchandani et al.'s** proposed model represents its own step towards advancement in healthcare technology, offering a comprehensive solution for monitoring vital health parameters, addressing environmental risks, and facilitating effective communication between patients and caregivers. Through its innovative design and functionality, the model holds the potential to revolutionize patient care and support for immobile individuals, ultimately improving outcomes and quality of life across diverse healthcare settings**.**

In the study of **Al-Dahoud et al.,** The global demographic landscape is undergoing a profound transformation, characterized by a burgeoning population of elderly individuals necessitating regular health monitoring. Against this backdrop, the development of e-health monitoring systems has assumed paramount importance in enhancing the quality of life for this demographic. Wearable devices have emerged as a preferred solution for remote health monitoring, owing to their inherent convenience and user-friendly nature. However, the affordability of such devices remains a significant concern, particularly for elderly individuals grappling with limited financial means.To address this challenge, this paper proposes a novel and cost-effective design for an IoT embedded system tailored for monitoring the physiological signals of elderly individuals within their homes or smart cities. Leveraging the principles of the Internet of Things (IoT), which seeks to extend network connectivity and data exchange to everyday objects, the proposed system offers an embedded stand-alone solution. It utilizes readily available off-the-shelf components to capture a diverse array of physiological signals, including heart rate, temperature, body moisture, respiration rate, and patient motion.The system processes these signals autonomously, ensuring the integrity and reliability of the collected data, before transmitting it via RF-transmitters to the designated treating physician. The transmission can take the form of a file or SMS message, facilitating seamless communication and data sharing. Unlike traditional approaches that rely on centralized servers for data processing, the proposed system operates independently, eliminating the need for complex infrastructure and reducing associated costs.Preliminary testing of the system's main sensors, encompassing heart rate, respiration, and motion, has yielded promising results, validating its efficacy and potential for real-world application. By democratizing access to remote health monitoring capabilities, this innovative IoT embedded system holds the promise of revolutionizing elderly care, empowering individuals to proactively manage their health and well-being in an affordable and accessible manner.

In the study of **Hew and Ramasamy (2022),** the development of a sophisticated smart health monitoring system comprising a wearable device and a complementary mobile application named MyHealth is detailed. Aimed at addressing the pressing issue of inadequate healthcare resources for the elderly, the wearable device is meticulously crafted with cost-effective components, including an integrated pulse and oxygen saturation sensor (MAX30102), a temperature sensor (LM35), and a Bluetooth-enabled microcontroller.The ingenuity of the developed wearable device lies in its ability to seamlessly interface with the MyHealth application via Bluetooth Low Energy. This seamless connectivity facilitates real-time measurement and monitoring of vital signs such as pulse rate, oxygen saturation, and body temperature, empowering users with timely insights into their health status. In the event of deviations from normal parameters, the application promptly alerts authorized individuals, enabling swift intervention and proactive healthcare management.Furthermore, the MyHealth application serves as a centralized platform for accessing and managing health data, offering authorized individuals comprehensive insights into the wearer's health status. Through secure authentication protocols, designated caregivers and healthcare professionals can remotely monitor vital signs and track health trends, thereby enhancing collaborative healthcare management.The system's robustness and reliability are further underscored by its calibration against commercial medical devices, ensuring accuracy and consistency in health monitoring. Rigorous testing involving diverse user groups, including the elderly, has demonstrated commendable accuracy levels, with pulse rate accuracy at 6 beats per minute, oxygen saturation accuracy at 1%, and body temperature accuracy at 1.3°Celsius compared to premium-priced alternatives.By showcasing the viability of IoT implementation in the healthcare sector at an affordable cost, this paper paves the way for broader adoption and integration of IoT-driven solutions. Beyond its technological prowess, the smart health monitoring system holds the promise of revolutionizing elderly care, promoting proactive health management, and ultimately enhancing the overall quality of life for the elderly population.

Local Literature

Rosallan et al., (2023) Vital sign monitoring could help to decrease loss of life due to early diagnosis of vital sign irregularity, especially to hospitalized patients and home-based patients. Vital signs are an important component in monitoring the patient's condition. The proponents came up with an android application used to monitor the data results gathered from the wearable device. Only registered persons can access the data result of the vital signs, such as the patient, doctors and relatives. The data results gathered by the wearable device are automatically stored on the firebase database if it has an internet connection. Otherwise, if the internet connection is lost, the collected data results of the vital signs are automatically stored on the local storage of the patient's smartphone. For every send of the data in offline mode, it will generate a metadata file. By clicking the sync button, all metadata will automatically delete and the results are stored to the firebase database. The user or patient can also generate *.csv file to back up the files. The device must always be connected to the Bluetooth of the patient's smartphone for the synchronization of data results. This system also notifies the doctors and the relatives about the condition of the patient. If the system detects an irregularity, it will automatically send an SMS notification to the doctor and the relatives of the patient and if the blood pressure is above normal, the system automatically dials the inputted number of the hospital.

STATEMENT OF THE PROBLEM

This study endeavors to tackle the communication and assistance challenges encountered by individuals facing mobility impairments, necessitating adhered solution to enhance their daily interactions and accessibility. The initiation of a Multi-Mode Bending Flex Communication System using Arduino Mega with SMS Module addresses communication and physical barriers, accommodating individuals with mobility limitations.

1. What are the essential components and design specifications of the Multi-Mode Bending Flex Communication System using Arduino Mega with SMS Module?

    1.1 2D Design

    1.2 3D Design

2. How will the fabrication process of the Multi-Mode Bending Flex Communication System with Arduino Mega and SMS Module be executed?

2.1 Close Loop Control System Diagram

2.2 Schematic Diagram

2.3 Microcomputer Assembly Design

2.4 Software Flowchart Design

3. What functionalities and features will be integrated into the Multi-Mode Bending Flex Communication System using Arduino Mega with SMS Module?

3.1 Hardware Functionality

3.2 Software Functionality and

3.3 Prototyping Testing Procedure

4. How can the reliability and robustness of the Multi-Mode Bending Flex Communication System using Arduino Mega with SMS Module be ensured?

4.1 Sustainability

4.2 Portability

4.3 Safety

4.4 Economy

4.5 Engineering Standards

5. What is the perception of the target user of the Development of Multi-Mode Bending Flex Communication System Using Arduino Mega and SMS Module?

5.1 Data Analysis

5.2 Survey Instrument Procedure

5.3 Survey Instrument

5.4 Statistical Research Tool

SIGNIFICANCE OF THE STUDY

This study holds significant importance in shedding light on the practical implementation and compatibility aspects of the microcontroller and database components within the Multi-Mode Bending Flex Communication System utilizing Arduino Mega with SMS Module. Through a comprehensive examination of the effectiveness of the materials employed, this research aims to provide a deeper understanding of the system's technical feasibility.

Academics: This research contributes to academia by offering valuable insights into the practical implementation and compatibility of the microcontroller and database components within the Multi-Mode Bending Flex Communication System. By thoroughly assessing the effectiveness of the utilized materials, scholars and researchers can gain a comprehensive understanding of the system's technical viability, thereby enriching their knowledge and comprehension of assistive technology development.

Readers: For general readers, this study provides valuable insights into the practical implementation and compatibility of the microcontroller and database components within the Multi-Mode Bending Flex Communication System. By comprehensively examining the effectiveness of the materials utilized, readers gain a deeper understanding of the system's technical viability, aiding in their knowledge and understanding of assistive technology development.

Users: Particularly for individuals with mobility impairments, the significance of the Multi-Mode Bending Flex Communication System lies in its ability to enhance communication capabilities. This research ensures that users can navigate daily tasks with greater ease and confidence, fostering independence and improving their quality of life. The system's compatibility and effectiveness contribute to its usability, empowering users to communicate efficiently and effectively.

Elderly: This study's significance lies in its potential to address the challenges associated with aging and mobility limitations among the elderly population. By offering a comprehensive communication solution tailored to their needs, elderly individuals can maintain connections with caregivers, family members, and healthcare providers more easily. The practical implementation of the system ensures that elderly users can access assistance and support whenever needed, promoting their well-being and autonomy.

Immobile Individuals: The Multi-Mode Bending Flex Communication System represents a significant advancement in assistive technology for immobile individuals. This research underscores the importance of inclusivity and accessibility, ensuring that immobile individuals have the means to communicate and interact with their environment effectively. By empowering immobile individuals with enhanced communication capabilities, the system promotes inclusivity and facilitates greater engagement in daily activities, ultimately enhancing their overall quality of life.

RESEARCH HYPOTHESIS

The researchers hypothesized that Arduino Mega is an effective electronic microcomputer device to make the Multi-Mode Bending Flex Communication System with GSM SIM 808 Module functional.

SCOPE AND LIMITATIONS

This study primarily aims to evaluate the effectiveness of a Multi-Mode Bending Flex Communication System utilizing an Arduino Mega 2560 microcontroller and an SMS module. The research targets participants within the context of its practical application, focusing on the system's ability to monitor, classify, and transmit data based on flex sensor inputs. Specifically, the investigation will explore the system's capacity to interpret bending gestures across multiple modes and communicate relevant information via SMS. However, certain limitations constrain the scope of this project.

The study is limited by the hardware specifications of the Arduino Mega 2560 microcontroller (operating voltage: 5V) and the SMS module (operating voltage: 3.4V - 4.4V). Any constraints inherent in these components may affect the system's overall performance and functionality, particularly in terms of voltage compatibility. Variations in the quality and sensitivity of flex sensors may impact the accuracy and reliability of gesture interpretation, potentially leading to inconsistencies in communication. Additionally, the voltage requirements of the flex sensors may pose limitations on their integration with the Arduino Mega 2560 microcontroller.

The software algorithms developed for gesture interpretation and message transmission are subject to limitations in processing power and memory capacity, which may restrict the complexity and efficiency of the system.The utilization of Arduino IDE and the C++ programming language for software development, along with Blynk.io and generic SMS messaging for communication, imposes constraints on the system's capabilities. These tools may have limitations in terms of customization, scalability, and compatibility with external systems, which could impact the system's overall functionality and adaptability.Due to the scope of the project, the software may lack advanced features such as facial recognition or video recording, limiting the system's capabilities beyond communication and gesture interpretation.

Despite these limitations, the study focuses on its core objective of evaluating the Multi-Mode Bending Flex Communication System's communication capabilities, prioritizing its practical application in monitoring and transmitting data based on flex sensor inputs.

Definition of Terms

Flex Sensor: A flexible sensor capable of detecting subtle movements and gestures. Often used in wearable applications for gesture recognition.

Arduino Mega 2560: A microcontroller board based on the ATmega2560 microcontroller, widely used in electronics projects for its versatility and ease of programming.

Mobility Impairments: Conditions that limit a person's ability to move or manipulate objects independently, often requiring assistive devices or technologies for mobility assistance.

Intuitive Gesture Recognition: The ability of a system to interpret gestures naturally, without the need for explicit commands or inputs, enhancing user interaction and usability.

Internet of Things (IoT): The network of interconnected devices and objects that can collect and exchange data, enabling remote monitoring, control, and automation of various systems and environments.

Transmission Mechanisms: Methods or protocols used to transmit data from one point to another, such as wireless communication, wired connections, or networking technologies.

Cloud Repository: A centralized storage system hosted on cloud infrastructure, allowing users to store, manage, and access data remotely over the internet.

Biometric Verification: Authentication method that uses unique biological characteristics, such as fingerprints, iris patterns, or facial features, to verify a person's identity.

Conceptual Framework: A theoretical structure or model used to organize and interpret data or phenomena within a particular field of study or research.

Real-Time Display: Presentation of data or information as it is processed or generated, providing immediate feedback or updates to users.

ECG Module: Electronic module capable of recording and analyzing electrocardiogram (ECG) signals, commonly used in medical devices for monitoring heart activity.

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GSM Technology: Global System for Mobile Communications technology, a standard for cellular communication widely used for voice and data services in mobile devices.

Systems Architecture: The structure or arrangement of components within a system, defining how they interact and function together to achieve specific objectives.

2D Project Design: Visualization of a project or system in two dimensions, often used to plan layouts, interfaces, or schematics.

3D Project Design: Visualization of a project or system in three dimensions, providing a more immersive and realistic representation for planning, design, or modeling purposes.

Experimental Approach: Research methodology focused on conducting experiments to test hypotheses, gather data, and validate theories or concepts.

Thorough Evaluation: Comprehensive assessment or examination of a system, process, or product to determine its effectiveness, performance, and quality.

Systems Development Technique: Methodology or approach used to develop and implement systems or software, often involving iterative processes for refinement and improvement.

Iterative Process: Approach to problem-solving or development that involves repeating cycles of planning, execution, evaluation, and adjustment to achieve desired outcomes.

Research Design: Overall plan or strategy for conducting research, including the selection of methods, tools, and procedures to address research questions or objectives.

Hardware Functionality: The capabilities and performance of hardware components within a system, determining their suitability for specific tasks or applications.

Prototype Reliability: The degree to which a prototype system or product can consistently perform as intended under various conditions, indicating its trustworthiness and dependability.

Autonomy: The ability of a system or device to operate independently or with minimal external control or intervention.

Quality of Life: Overall well-being and satisfaction experienced by individuals, influenced by factors such as health, comfort, security, and access to resources.

Database Components: Elements or structures within a database system, including tables, fields, indexes, and relationships, used to organize and manage data.

Microcontroller: Integrated circuit containing a processor core, memory, and input/output peripherals, used to control and manage electronic devices or systems.

Assistive Technologies: Devices, tools, or systems designed to enhance the functional abilities and independence of individuals with disabilities or impairments.

Accelerometer: Sensor capable of measuring acceleration forces, commonly used in electronic devices for motion detection and orientation sensing.

LCD: Liquid Crystal Display, a flat-panel display technology commonly used for visual output in electronic devices such as monitors, TVs, and digital signage.

ADXL335: A specific model of accelerometer sensor, known for its high resolution and low power consumption, suitable for various motion-sensing applications.

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Technical Viability: The feasibility or practicality of implementing a technology-based solution, considering factors such as functionality, performance, compatibility, and resource requirements.

SMS Transmission: The process of sending short message service (SMS) messages over a cellular network, enabling text communication between mobile devices or applications.

Cutting-Edge Technologies: Advanced or innovative technologies that represent the forefront of development or research in a particular field, often characterized by their novelty, complexity, and potential for transformative impact.

High-Fidelity Speaker: A speaker system capable of reproducing audio with high accuracy and fidelity, preserving the original quality and nuances of the sound source.

SIM808 GSM GPRS Module: A compact electronic module incorporating GSM (Global System for Mobile Communications) and GPRS (General Packet Radio Service) capabilities, used for wireless communication in applications such as IoT (Internet of Things) devices, tracking systems, and remote monitoring solutions.

Chapter 2

Methods

In this chapter, we delve into the methodologies employed to gather the indispensable data essential for the completion of this investigation. Drawing inspiration from an existing multi-mode bending flex communication system, this study adopts an experimental approach. Two pivotal aspects that demand scrutiny are the effectiveness of the materials employed for this prototype and their relevance to the existing multi-mode bending flex communication system.

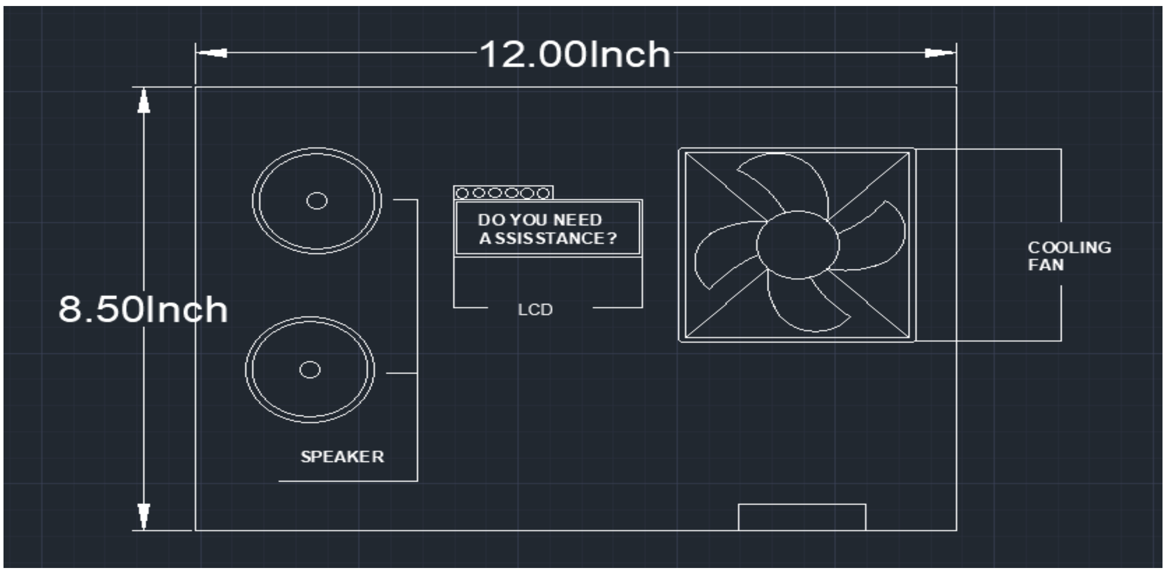
To conduct this investigation, the researchers will utilize the Experimental Prototyping Method. This method involves constructing a prototype as a means of testing its viability, which may ultimately be either accepted or rejected. According to **Smith (2021),** prototypes are integral to the process of developing a new product as they address concerns and ensure thorough evaluation through user interaction, thereby ensuring the accuracy and testability of the prototype.

The prototyping model serves as a Systems Development Technique (SDM) wherein an initial version of the final system or product is created, tested, and refined as necessary until an acceptable prototype is achieved. This iterative process allows for continuous refinement, particularly beneficial when not all product requirements are known upfront. Through iterative trials and refinements, both users and developers collaboratively contribute to the evolution of the prototype..

Sequential Phases in Prototyping

1. Basic Requirement Identification
2. Developing the Initial Prototype
3. Review of the Prototype
4. Revise and Enhance the Prototype

2D PROJECT DESIGN



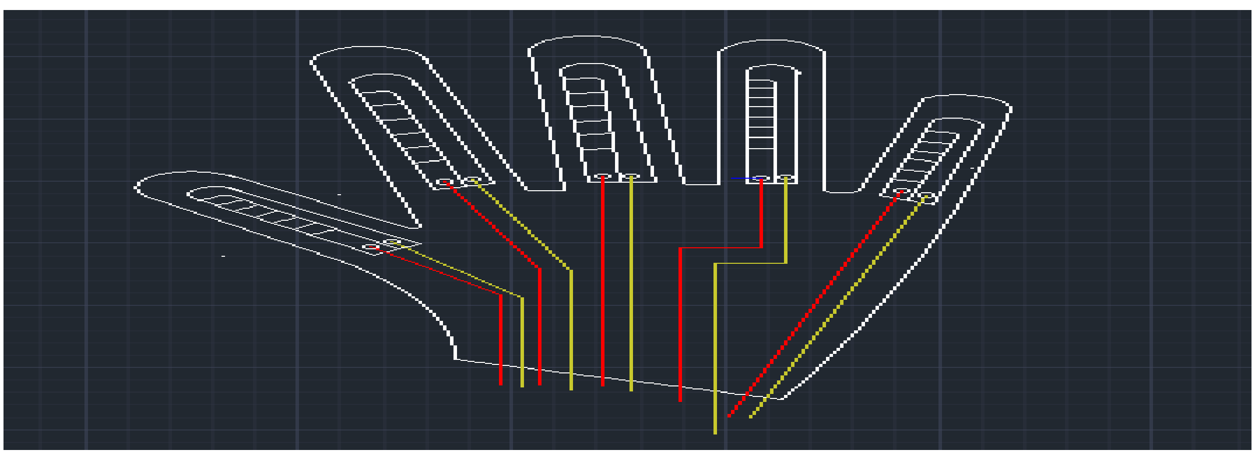
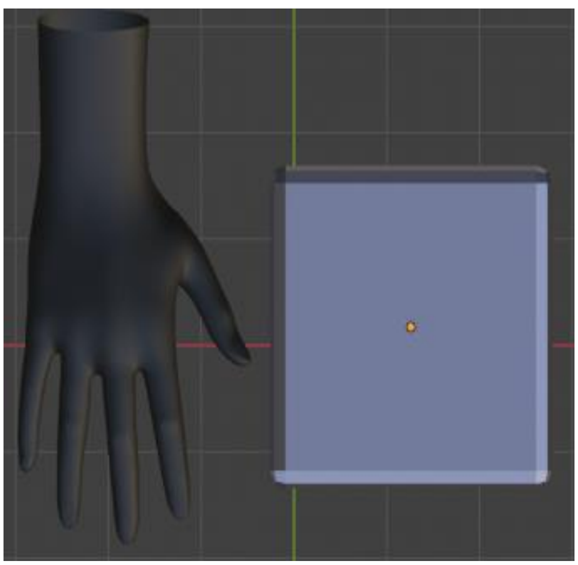
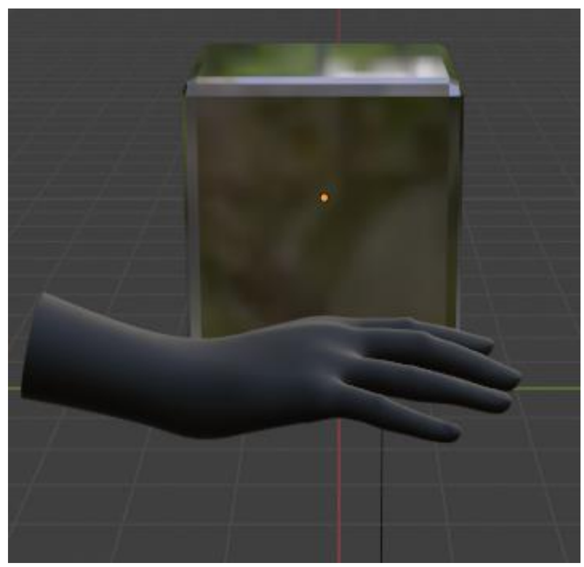


Figure 2.0 Multi Mode Bending Flex Communication System Model

To further visualize the overall design, the researchers transferred the rough ideas and sketches to a 2D model. The figure 2.0 shows the 2D model of the Multi Mode Bending Flex Communication System.

3D PROJECT DESIGN





TOP VIEW **SIDE VIEW**

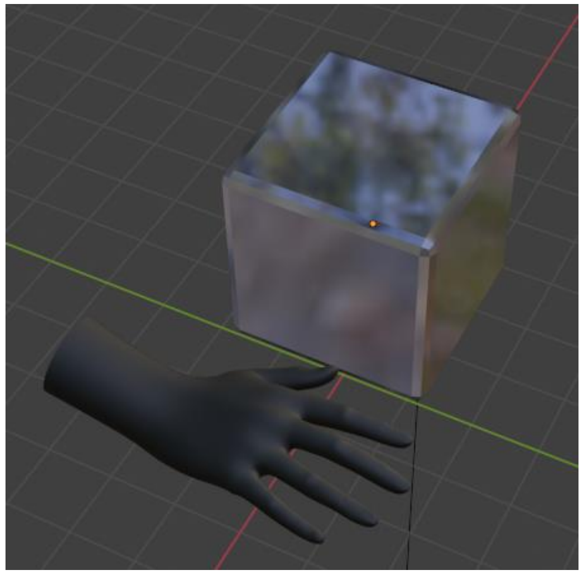


Figure 2.1 Multi Mode Bending Flex Communication System Model

AERIAL VIEW

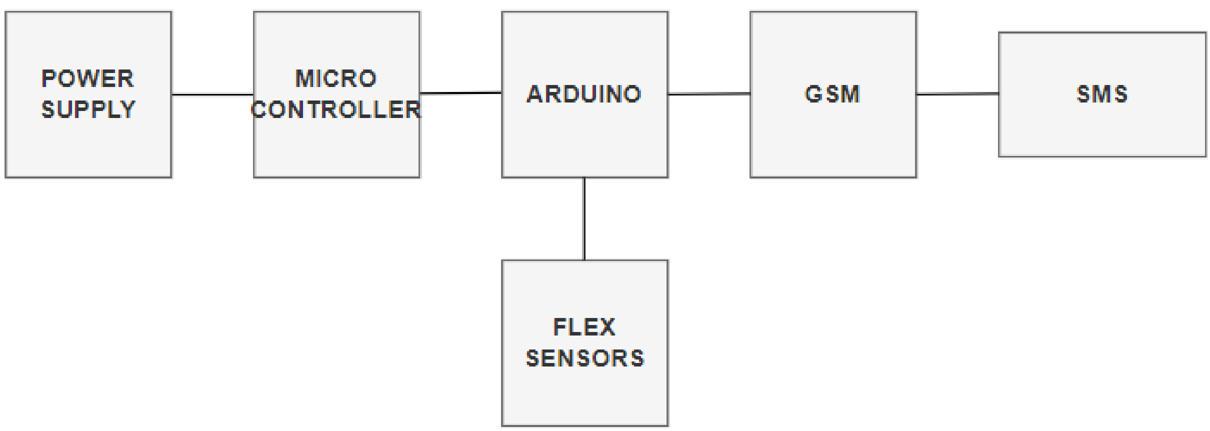


Figure 2.2 Multi Mode Bending Flex Communication System Using Arduino Mega 2560 and SMS SIM 808 Module

RESEARCH DESIGN

The proposed research focuses on the communication hurdles encountered by individuals with mobility impairments. It seeks to develop a Multi-Mode Bending Flex Communication System using Arduino Mega 2560 and GSM SIM 808 module. This system leans toward the users to communicate effectively through flexible gestures and movements, thereby enhancing their accessibility and interaction in various environments. A comprehensive literature review will be conducted to explore prior work on assistive technologies, Arduino-based communication systems, and flexible sensor technologies. Existing research on communication methods for individuals with mobility limitations will be examined to identify gaps and opportunities for innovation.

The methodology encompasses various stages: hardware development involves designing and assembling components like the Arduino Mega 2560, GSM SIM808 module, and flexible sensors for gesture recognition. Software development focuses on creating algorithms and a user interface for gesture interpretation, message transmission, and feedback. Prototype testing is conducted to assess the system's functionality, accuracy, and usability across simulated and real-world scenarios. Feedback from users with mobility impairments is gathered to evaluate the system's effectiveness and user experience. Lastly, performance evaluation measures predefined metrics such as communication speed, accuracy, and user satisfaction to gauge the system's overall efficacy.

The Multi-Mode Bending Flex Communication System will be structured around the Arduino Mega 2560 microcontroller, complemented by the GSM SIM808 module for wireless communication, and flexible sensors to detect gestures and movements. This architecture prioritizes simplicity, reliability, and adaptability to cater to diverse user needs and environments.

The analysis and discussion phase will involve thorough examination of testing results and user feedback to pinpoint the system's strengths, weaknesses, and areas for improvement. Discussions will revolve around the system's efficacy in overcoming communication barriers for individuals with mobility impairments, as well as its potential for practical implementation.

Drawing from the research findings, the conclusion will summarize the feasibility and effectiveness of the Multi-Mode Bending Flex Communication System. Recommendations will be provided for further development and refinement to enhance the system's functionality and usability in real-world settings.

FABRICATION OF THE PROTOTYPE

Closed-Loop Feedback Control Block Diagram

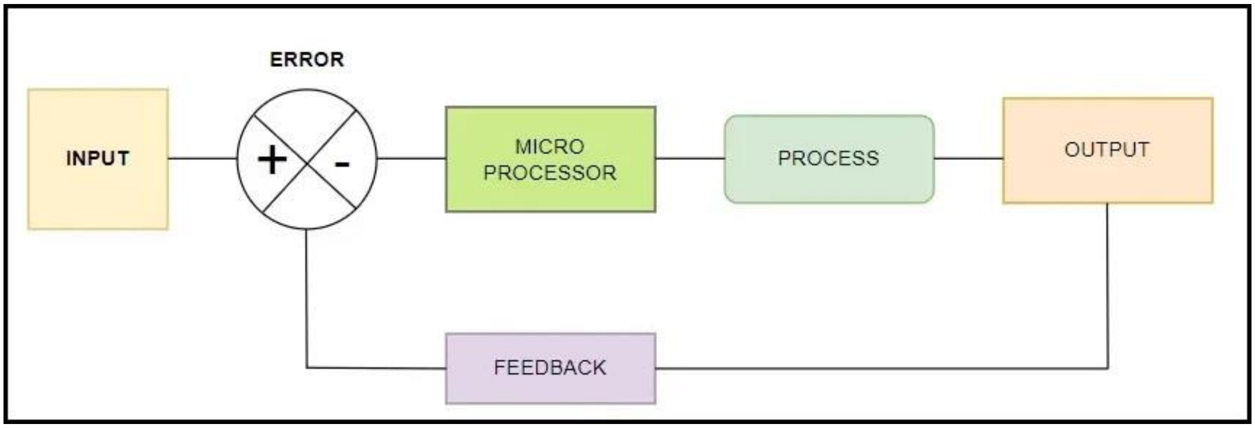
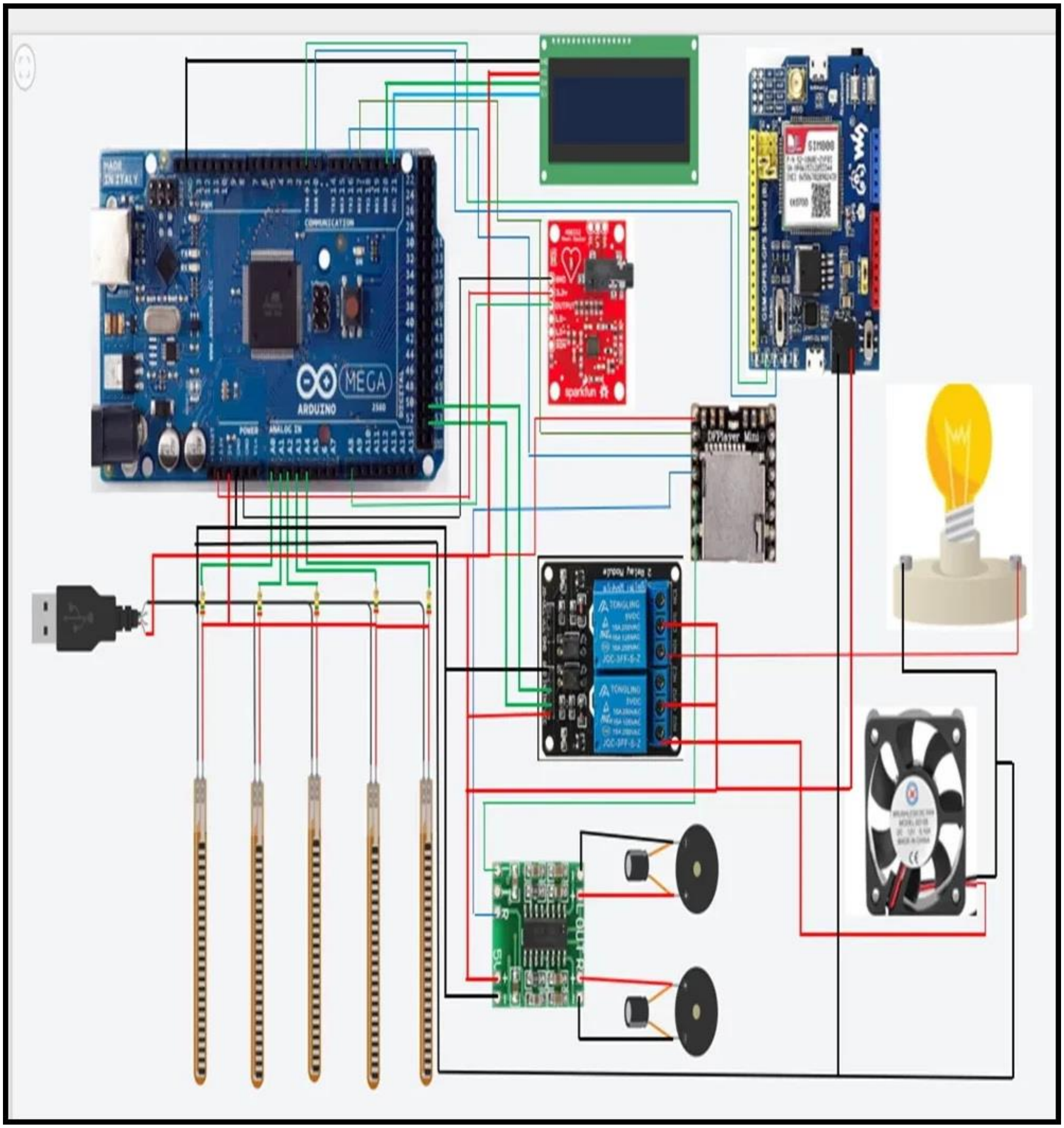


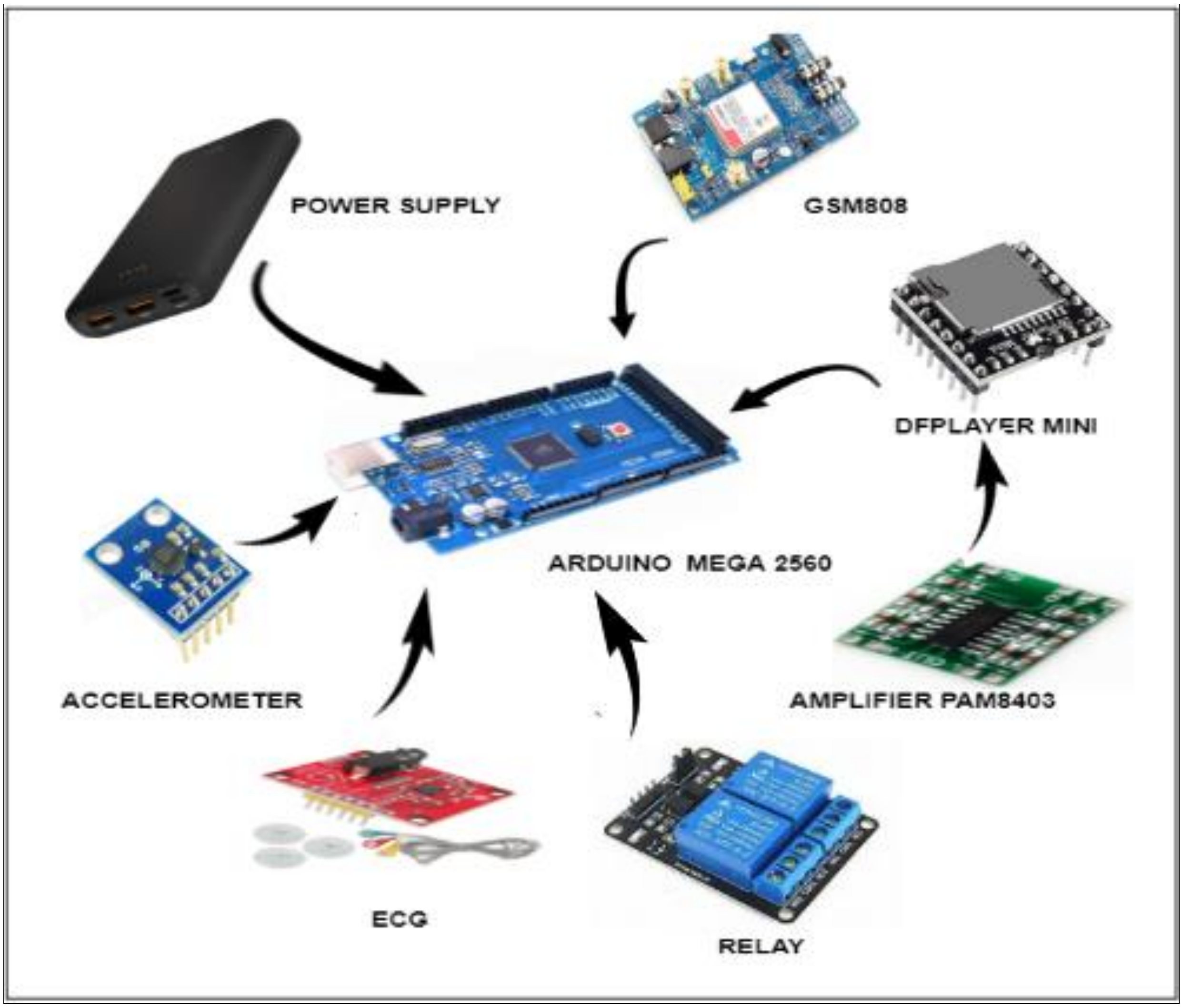
Figure 2.3 Control system

This study used a closed-loop feedback control system as its preferred methodology, facilitating precise and adaptive management of the experiment's components and outcomes. This system interconnects the experiment's materials, enabling continuous monitoring and adjustment of the input or control signal in response to deviations from a reference value. Such a feedback mechanism ensures self-correction and stability, allowing the system to effectively respond to environmental changes or disturbances while maintaining accuracy.

PICTURE SCHEMATIC DIAGRAM

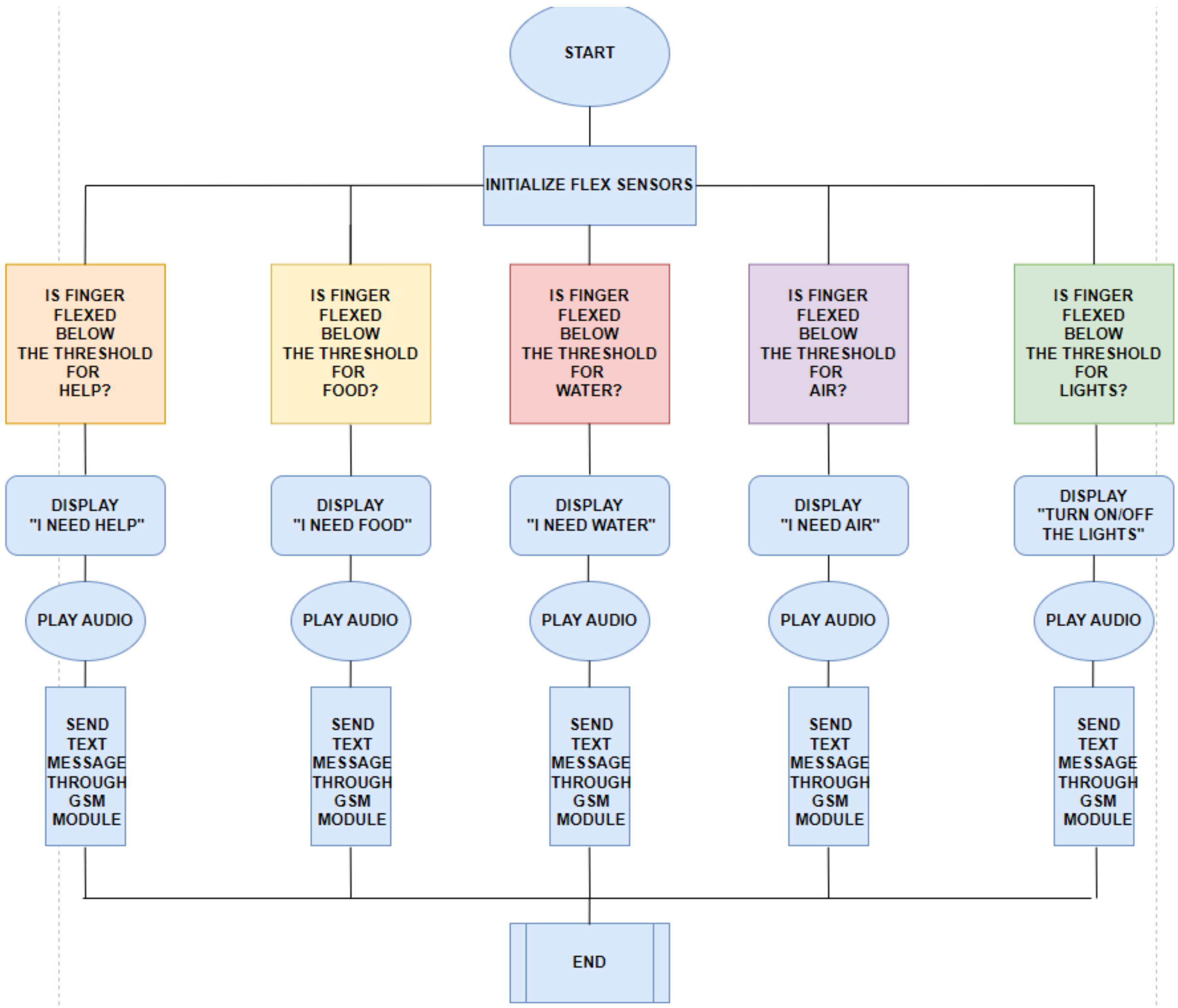


MICROCOMPUTER/ MICROPROCESSOR DESIGN ASSEMBLY



The setup features an Arduino Mega 2560 powered by a robust power bank, with data connectivity via the GSM SIM808 module for accessing the Blynk database. Various sensors collect data, with optional Wi-Fi or Bluetooth modules for extended connectivity. Additionally, a DFPlayer provides audio feedback triggered by sensor events, such as speaking messages when activated by the flex sensor.

SOFTWARE FLOW CHART DESIGN



HARDWARE FUNCTIONALITY

The proposed Multi-Mode Bending Flex Communication System will exhibit several key hardware functionalities tailored to facilitate seamless communication for individuals with mobility impairments. At its core, the system will integrate the Arduino Mega 2560 microcontroller, serving as the central processing unit for data interpretation and transmission. Complementing this, the GSM SIM808 module will enable wireless communication, allowing users to transmit messages and receive alerts in real-time. The system will be equipped with flexible sensors strategically placed to detect a range of gestures and movements, enabling intuitive interaction with the communication interface. Additionally, the inclusion of output modules such as LED indicators and auditory feedback devices will provide users with clear and accessible feedback. The system will also feature connectivity options, including Wi-Fi, enhancing its versatility and accessibility. Overall, the hardware functionality of the prototype will facilitate efficient and reliable communication, empowering users with enhanced accessibility and independence in their daily interactions..

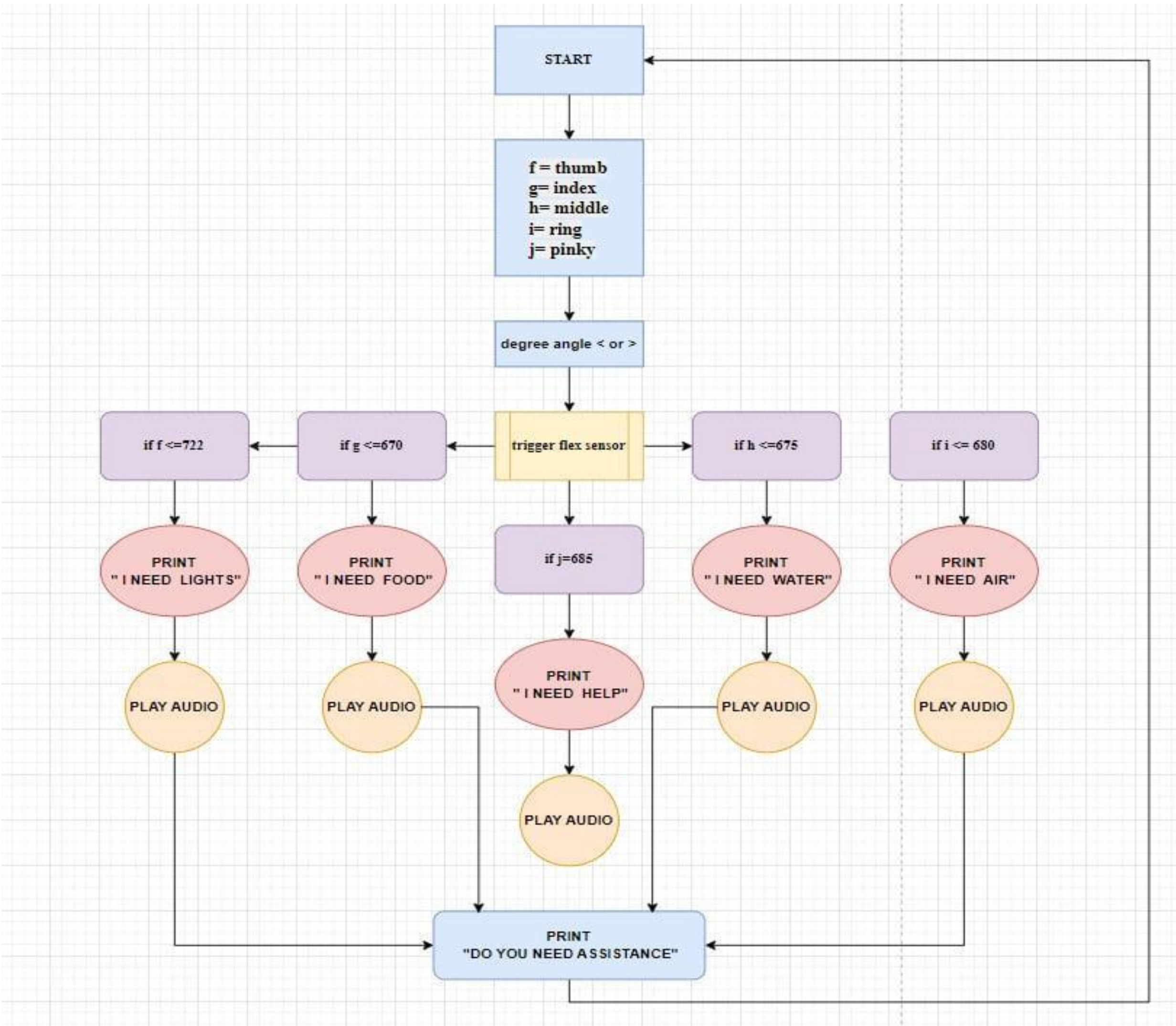
NAME OF THE HARDWARE	FUNCTION	SPECIFICATION
Arduino Mega 2560	Microcontroller	ATmega2560 microcontroller, 8-bit AVR architecture, 256 KB flash memory, 8 KB SRAM, 4 KB EEPROM, 54 digital input/output pins (including 15 PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), operating voltage: 5V, clock speed: 16 MHz.

Flex Sensors	Gesture and movement detection	Ultra-thin, bendable sensors, analog output, capable of detecting subtle movements and gestures, ideal for wearable applications, dimensions vary based on specific model and design.
ADXL355 Accelerometer	Motion sensing	High-resolution, low-power triaxial accelerometer, ±2 g to ±8 g selectable measurement range, high resolution (up to 20-bit), SPI and I2C interfaces, voltage supply: 2.0V - 3.6V, current consumption: 165 µA at 2.5V, dimensions: 3mm x 3mm x 1.2mm (L x W x H).
DFPLAYER MINI	Audio playback	Low-cost MP3 module with built-in amplifier, supports MP3 and WAV audio formats, onboard microSD card slot for audio storage, serial communication interface, working voltage: 3.2V - 5V, dimensions: 21mm x 17mm

GSM SIM 808 MODULE	Wireless communication	Quad-band GSM/GPRS module with integrated GPS functionality, SIM card slot, serial communication interface, operating voltage: 3.4V - 4.4V, temperature range: -40°C to +85°C, dimensions: 24mm x 24mm x 3mm.
LIQUID CRYSTAL DISPLAY I2C	Visual feedback	16x2 character LCD display with I2C interface, blue backlight, supports standard HD44780 command set, operating voltage: 5V, dimensions: 80mm x 36mm x 12mm.
Speakers	Audio output	Generic speakers for audio playback, impedance: 4 Watts 8 ohms, power rating varies based on specific model and design, dimensions: vary based on specific model and design.
5V Generic Powerbank	Power supply	Generic power bank with 5V output, capacity and dimensions

		vary based on specific model and design, typically equipped with USB ports for charging electronic devices, rechargeable lithium-ion battery.
12V Exhaust Fan		

LOOP FLOW CHART AUTOMATION DESIGN



PROTOTYPE TESTING PROCEDURE

The prototype testing procedure for the Multi-Mode Bending Flex Communication System focusesassess its functionality, usability, and performance before finalizing the product. This iterative process involves alpha and beta testing stages to identify any issues, gather user feedback, and implement necessary modifications.

During the alpha testing phase, the system's functionality and performance will be evaluated in a controlled environment. The following procedures will be conducted:

- Test the hardware components, including the Arduino Mega 2560, Flex Sensors, ADXL355 Accelerometer, DFPlayer Mini, GSM SIM 808 Module, Liquid Crystal Display (LCD) I2C, and Speakers, to ensure proper functionality and integration with the software algorithms.
- Assess the accuracy and responsiveness of the system in detecting and interpreting gestures using the flexible sensors and accelerometer.
- Evaluate the reliability and efficiency of the message transmission process, including sending and receiving SMS notifications via the GSM module
- Test the user interface design and usability of the system, ensuring intuitive interaction and clear feedback for users with mobility impairments.
- Measure the system's performance metrics, such as communication speed, accuracy of gesture recognition, and system responsiveness, while also assessing its reliability in various usage scenarios.

Following the alpha testing phase, beta testing will be conducted in real-world settings to further evaluate the system's functionality and performance. The procedures for beta testing include:

- Deploy the Multi-Mode Bending Flex Communication System in real-world environments, such as homes or care facilities, to assess its performance in practical situations.

- Gather feedback from users, including individuals with mobility impairments and caregivers, to understand their experiences with the system and identify any usability issues or areas for improvement.
- Monitor the system's performance over an extended period to evaluate its long-term reliability, durability, and stability in everyday use.
- Iterate on the system design and functionality based on user feedback and field testing results, making necessary adjustments to enhance its effectiveness and user satisfaction.

By conducting thorough alpha and beta testing, the Multi-Mode Bending Flex Communication System can undergo comprehensive evaluation and refinement, ensuring that it meets the needs of users and provides a reliable solution for communication among individuals with mobility limitations

HARDWARE TEST

The hardware testing phase involves evaluating the functionality and performance of the various components comprising the Multi-Mode Bending Flex Communication System. Specific hardware elements such as the Arduino Mega 2560, Flex Sensors, ADXL355 Accelerometer, DFPlayer Mini, GSM SIM 808 Module, Liquid Crystal Display (LCD) I2C, and Speakers undergo thorough examination to ensure proper operation. Initial operation of the prototype entails testing the mobility of the flexible sensors and accelerometer, validating communication protocols among components, calibrating the system for accurate gesture recognition, assessing autonomous operation capabilities, and analyzing data records. Furthermore, voltage distribution across each hardware component is meticulously examined using a Multimeter to verify operational requirements. Additionally, an analog weighing scale is employed to measure the load capacity and kinematics of the system, ensuring optimal performance across various usage scenarios.

Table 2 Hardware Materials

Arduino Mega 2560	12V Exhaust Fan
Flex Sensor	Liquid Crystal I2C
GSM SIM 808 Module	Speaker
ADXL335 Accelerometer	DFPlayer Mini
5V Power Bank	

SOFTWARE TEST

For software testing in the Multi-Mode Bending Flex Communication System, a comprehensive approach is essential to verify its functionality and performance. The testing procedures typically include the following steps: developing test cases to cover various scenarios and functionalities, configuring software settings to ensure compatibility and optimal performance, conducting unit testing to evaluate individual software modules, integrating components to assess their interaction and interoperability, validating system requirements to ensure they align with user needs and expectations, and documenting the testing process and results for future reference and troubleshooting. The purpose of this testing process is to validate the reliability and effectiveness of the software algorithms and user interface in facilitating communication for individuals with mobility impairments and the elderly.

Table 2 Software Materials

Arduino IDE	AutoCAD
Blynk.io	Blender
SMS Messaging	

PROTOTYPE RELIABILITY

Sustainability

The reliability of the Multi-Mode Bending Flex Communication System prototype is essential for ensuring its sustainability, portability, safety, economy, and adherence to engineering standards. Sustainability is upheld through the system's ability to efficiently carry out communication tasks, reducing waste and enhancing overall effectiveness. To maintain reliability, regular inspections and maintenance procedures are necessary

Portability

Portability is facilitated by the system's compact design and flexible hardware and software configuration, ensuring reliable performance in diverse environments

Safety

Safety measures are integrated into the system to ensure dependable operation, with adherence to manufacturer instructions and safety protocols being crucial.

Economy

Economically, the system enhances productivity and reduces costs, contributing to economic growth and competitiveness in various sectors. The estimated cost to complete the prototype is 12,000 PHP.

Engineering Standard

Engineering standards, such as those outlined by the PEC regulations, are followed to ensure the safety and effectiveness of the prototype's design and implementation, aligning with established industry standards and best practices.

DATA ANALYSIS

Research Survey Instrument Procedure

A systematic approach to data collection and analysis is essential for the successful implementation of the research survey instrument procedure in the context of the "Multi-Mode Bending Flex Communication System using Arduino Mega 2560." This procedure is for gathering valuable insights and feedback to optimize the functionality and performance of the proposed system. The steps involved in the research survey instrument procedure are outlined below:

- Define the Research Objectives: Clearly articulate the goals and objectives of the research, outlining the intended functionalities and applications of the bending flex communication system. Identify specific tasks and operations that the system is expected to perform, such as data transmission, sensor readings, and audio playback.
- Design the Survey Instrument: Develop a comprehensive survey instrument comprising various data collection tools,including questionnaires, checklists, and observation forms. Determine the target audience for the survey, such as potential users, developers, or stakeholders involved in the implementation of the system. Incorporate questions and prompts aimed at eliciting feedback on different aspects of the system, including user experience, performance metrics, and potential areas for improvement.

- Distribution and Data Collection: Disseminate the survey instrument to the identified target audience through suitable channels, such as online platforms, email, or in-person interviews. Ensure that the survey is accessible and user-friendly, allowing participants to provide detailed and meaningful responses. Collect and compile the survey responses systematically, organizing the data for further analysis and interpretation.

- Data Analysis and Insights: Analyze the collected data to identify trends, patterns, and insights regarding the usability, effectiveness, and performance of the bending flex communication system.Utilize statistical methods and qualitative analysis techniques to derive meaningful conclusions from the survey findings. Identify strengths, weaknesses, opportunities, and threats associated with the system, highlighting areas for improvement and optimization.
- Recommendations and Conclusion: Based on the survey results and data analysis, formulate actionable recommendations to enhance the functionality, reliability, and user experience of the bending flex communication system. Summarize the key findings and conclusions drawn from the survey, emphasizing the significance of the research and its implications for future development and implementation.Provide a comprehensive overview of the research outcomes, highlighting the potential benefits and contributions of the bending flex communication system to the field of technology and communication.

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Survey Instrument

Please take a few moments to answer the following questions:

Sex: ☐ Female ☐ Male

Age:

Educational Attainment:

What is the functionality of the prototype which indicates the acceptability and agreeability of its function?

Functionality

INDICATORS	4 (SA)	3 (A)	2 (DA)	1 (D)
1. The Multi-Mode Bending Flex Communication System using Arduino Mega 2560 with GSM Module is modern and an Innovative system				
2. The Multi-Mode Bending Flex Communication System using Arduino Mega 2560 with GSM Module are				

convenient for its every user (Elderly and Immobile individuals)				
3 The Multi-Mode Bending Flex Communication System using Arduino Mega 2560 with GSM Module is easy to operate				
4. The Multi-Mode Bending Flex Communication System using Arduino Mega 2560 with GSM Module is effective in terms of its security				
5. Enhancing the communication capabilities of the elderly and immobile individuals are beneficial both to the user and the family/caretaker of said user.				

What are the factors that contribute to the reliability of the multi-mode bending flex communication system utilizing Arduino Mega 2560 with GSM SIM 808 module

Reliability

INDICATORS	4 (SA)	3 (A)	2 (DA)	1 (D)

1. The necessary materials are readily accessible in the market. Additionally, the software tools, such as Arduino IDE are freely available for use (Sustainable)				
2. The system has room for improvement over time. Future updates can introduce additional features or enhance functionality to better serve elderly individuals and those with mobility issues (Portable)				
3. All components and materials used in the system adhere to safety standards, ensuring that they pose no harm to elderly individuals or those with mobility challenges (Safety)				
4. Efforts are made to maintain the affordability of the project, ensuring that it remains accessible to those in need without imposing significant financial burden (Economy)				

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5. The system is designed to comply with security regulations and guidelines, safeguarding user information and ensuring adherence to industry standards (Engineering Standard)				

Statistical Research Tool

The researchers use purposive sampling technique and descriptive statistics method to interpret the collected data using surveying method.

The method of evaluation uses weighted mean and percentage formula.

Weighted Mean Formula ($\bar{x}$)

$$x=\sum fx / N$$

Where; ($\bar{x}$) = weighted mean

f = frequency

x = Likert rank

N = Total respondents

Prototype Formula (P)

$$P = \frac{n}{N} x\ 100\ \%$$

Where;

P = Percentage

n = sub-item

N = Total respondents

According to **George (2024)** identifies a form of nonprobability sampling called the purposive sample, also referred to as the judgment or expert sample. The main objective of employing a purposive sample is to create a sample that is intended to be representative of the entire population. The selection of a nonrandom sample from various elements to mirror the population is typically achieved through population credibility. A tool commonly utilized for gauging opinions or attitudes in surveys is the 4-Point Likert Scale, which offers four response choices. Respondents express their level of agreement or disagreement by selecting one of four options: Agree, Strongly Agree, Disagree, or Strongly Disagree.

Table 4 Four-point Likert Scale Method

Rank	Scale Interval	Interpretation
4	3.51 - 4.00	Strongly Agree (SA)
3	2.51 - 3.50	Agree (A)
2	1.51 - 2.50	Less Disagree (LD)
1	1.00 - 1.50	Disagree (D)

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